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FORMAL DISCUSSION—PAPER I-3

Impact on Salmon of Spraying Insecticide Over Forests

P. F. Elson and C. J. Kerswill

Discussion by

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THIS paper by ELSON and KERSWILL is an excellent example of a comprehensive, thorough, and painstaking examination of the impact of DDT on the aquatic environment and its inhabitants. In technically sound fashion, this field study examines the environmental conditions that prevailed before, during, and after an extensive and prolonged program of aerial spraying to control the ravages of spruce budworm in New Brunswick, Canada, forests.

Sensing the biotic responses to these challenges has required probing in many related directions: (*a*) to assess the direct toxic effects on several growth stages of salmon, both wild and hatchery-reared, (*b*) to detect occurrence of delayed mortality and sublethal effects, (*c*) to evaluate responses in fishes other than salmon, (*d*) to measure changes in insect and other invertebrate populations, the feeding responses of surviving salmon, and resulting growth characteristics, and (*e*) to delineate the summation of these responses in terms of migrant salmon returning to spawning streams.

These approaches, which in part date back to 1950—2 yr preceding initial DDT spraying on these watersheds—cover a continuous 15-yr period of observation up to the present. It is believed that observations of this great a duration on such problems have not been made elsewhere on this planet. Accordingly, the New Brunswick studies have historical as well as scientific significance and have been a guide and example for similar studies elsewere.

In giving basic facts on the life history of the Atlantic salmon (*Salmo salar*), the authors aptly point to the special vulnerability of the fish. The young, hatching

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in the gravel, emerge at the time the forest spraying is in progress; they depend on food organisms that also are susceptible to the changing environment; and they remain potentially exposed in the river environment for their two or three years of freshwater existence.

With these facts as background, several points of special interest deserve comment. The losses of young salmon, as confirmed by both the *in situ* bioassays and the sampling of wild populations, are startling and devastating. DDT at 0.5 lb/acre (0.56 kg/ha) reduced populations of underyearling wild fish by 90 to 98 percent, small parr by 70 percent, and large parr by 50 percent. Applying DDT twice at one-half this rate per acre did not offer appreciable protection to the underyearlings examined.

Novel approaches were used to assess the impact on aquatic insects and the immediate and longer-range significance of this to food availability, feeding habits, and growth rates among young salmon. As shown graphically in the paper, the decline in both numbers and volume of biomass was immediate and catastrophic after spraying. However, it is notable that some insects apparently survived in resistant life-history stages, and this capability apparently explains the resulting increasing population numbers with decreasing biomass volume. Insects that generally are felt to be exacting in their water quality and other habitat requirements, such as stoneflies, mayflies, and caddisflies, were found to require up to four years for population recovery. Feeding habits of salmon changed after spraying so that they utilized the surviving biota. Influences of these circumstances on growth rates of salmon were beclouded by other still-unassessed environmental changes.

The New Brunswick program does not stand as a lone example of the many conflicting values that must be considered in such vast manipulations of the environment. The ravages of forest insects and related diseases have stimulated control programs at several points in the United States.

During 1964[1], 525,000 acres (212,464 ha) in the Salmon and Challis National Forests in Idaho were sprayed with DDT at either 0.5 lb/acre (0.56 kg/ha) or at 1 lb/acre (1.12 kg/ha) for control of spruce budworm. Chinook (*Onchorynchus tshawytscha*) and sockeye (*O. nerka*) salmon and steelhead trout (*Salmo gairdnerii*) utilize streams in the area so that problems of resource protection resemble those in New Brunswick. It is not surprising, then, that the monitoring program included many of the same procedures that were pioneered in New Brunswick. In addition, DDT levels were determined for stream water, adipose tissue, and rumen samples of big game, birds, terrestrial vegetation, and dairy products. Results of the aquatic monitoring program are not yet available.

Similarly, 71,678 acres (29,007 ha) in the Yellowstone River drainage basin in and downstream from Yellowstone Park were sprayed with DDT in 1957 for spruce budworm control[2]. Application rate was 1 lb/acre (1.12 kg/ha) over mountainous terrain that ranges up to more than 9,000 ft (2,743 m). The river and its tributaries have prized populations of cutthroat trout (*Salmo clarki*), rainbow trout (*S. gairdnerii*), brown trout (*S. trutta*), and mountain whitefish (*Prosopium williamsoni*). Although fish mortalities were not observed in inspections after spraying, changes in bottom invertebrate populations were drastic.

Except for differences in detail, in general, the changes were similar to findings in New Brunswick.

In 1963, a sizable program was carried out to control hemlock looper in mature forests in southwest Washington[3]. Sevin was used on 43,204 acres (17,484 ha), DDT on 26,606 acres (10,767 ha), Phosphamidon on 2,276 acres (921 ha), and *Bacillus thuringiensis* on 239 acres (96.7 ha). Streams in the area are used by spawning chinook (*Onchorynchus tshawytscha*), silver (*O. kisutch*) and chum (*O. keta*) salmon, and other game fishes. In addition, much of the land area drains to Willapa Bay, which produces Pacific oysters with an average annual value of over $4.4 million. The Dungeness crab fishery is worth an additional $0.2 million. These facts, and the presence on the watershed of a fish hatchery, deer, elk, and other wild animals, emphasized the need for extreme care in application of control agents and in monitoring effects. DDT levels in streams were found to decline steadily after treatment and frequently reached less than 0.0005 mg/l. on the same day. No significant mortalities were seen in fish, crayfish, or caddisflies. Oysters and clams from the Bay were negative for DDT, and Bay waters had no adverse effect on oyster larvae as shown by bioassay.

From these few examples, the salmonid fishes in the New Brunswick rivers seem to respond differently from those observed in other DDT-treated watersheds. One can wonder if differences in species tolerance are involved, or whether significant differences in mode of DDT application or in the duration and efficacy of post-treatment monitoring are involved. In any event, these differences cannot be determined because the history of occurrence and concentrations of DDT in all of these waters is not available. In any future studies, it is fundamental that information on DDT levels prevailing in the water during the critical periods be obtained.

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